

II. THE FAUNA OF THE UPPER DEVONIAN IN MONTANA.

PART 2. THE STRATIGRAPHY AND THE BRACHIOPODA.

BY W. P. HAYNES.

(PLATES III-VIII.)

A number of years ago Dr. P. E. Raymond undertook the description of the fauna of the Upper Devonian in Montana, basing his work upon collections made by Mr. Earl Douglass and himself for the Carnegie Museum. The first part, containing a description of the Cephalopoda and a few other fossils from the "Red shales," appeared in 1909 in these ANNALS.

In this, the second contribution to the subject, the writer describes the Brachiopoda, based on the material in the Carnegie Museum, supplemented by collections, which he has himself made for the Museum of Comparative Zoölogy, and describes the stratigraphy of the formation.

The writer is indebted to Dr. Raymond for many suggestions in the preparation of this work for publication.

STRATIGRAPHY.

The writer has made a study of the Three Forks Formation at its type-locality at Three Forks, Montana, and also throughout the Three Forks quadrangle and the neighboring region along the Missouri river in the Fort Logan quadrangle (See Plate III). In this report the distribution and stratigraphy of the formation will first be considered, and then the fauna will be discussed, with a detailed description of the brachiopods of the limestone and green shale members of the formation.

Three Forks Formation.

General Description.—Lying in apparent conformity upon the Jefferson limestone is a series of shales and limestones, which have been named by the late Dr. A. C. Peale the Three Forks Shales.¹ He described the formation in some detail, which may be briefly summarized by the following columnar section.

¹ Peale, A. C., Bull. U. S. G. S., No. 110, pp. 29-30, 1893.

	Yellow laminated sandstones.	25 ± feet.
Upper Shales	Greenish gray nodular limestones, Dark colored argillaceous limestones, Soft shaly black and purplish calcareous limestones..	45 feet.
	Fine green argillaceous shale.	30 "
Intermediate Limestone	Compact grayish brown limestone, weathers into orange debris and obscures lower shales.	15-20 feet.
Lower Shales	Reddish and brownish yellow argillaceous shales	$\frac{50}{145}$ "
		145 ± feet.

Dr. Peale noted the absence of fossils in the Lower Shales and the overlying limestone, and the great abundance of fossils of Devonian age in the Upper Shales, particularly in the calcareous portions. He also noted the presence of a band of black slate or shale in the section at the base of the Yellow Sandstone member at two localities, one near the Horseshoe Bend of the Missouri River near Rekap, and the other south of the Jefferson River near Antelope Creek.

The writer has visited both of these localities and has included sections measured at both places among the lists of sections given in the following pages.

Dr. Peale in summarizing his description of the Three Forks Shales noted the fact that they become more arenaceous to the east of Three Forks, as they pass into the Bridger Range, while they become more calcareous to the west on the north side of the Jefferson River.

This description given by Dr. Peale applies to the Three Forks Formation as seen in the northern part of the Three Forks quadrangle, but in the southern part the formation has changed and becomes more dominantly a limestone with argillaceous and arenaceous phases. Owing to the fact that the strata called the Three Forks Shales by Dr. Peale are a composite series and include limestones and shales and some sandstones, the writer feels that it is advisable to use the name "Three Forks Formation" which is applicable to the southern occurrences as well as to those about Three Forks.

The writer has found it possible to divide the Three Forks Formation into seven members, which are easily recognized by their lithologic characters and are present in all of the sections studied in the northern part of the quadrangle and the adjacent region to the north. This sevenfold division will be noted in the case of each section, so that a

COLUMNAR SECTIONS OF THE THREE FORKS FORMATION.

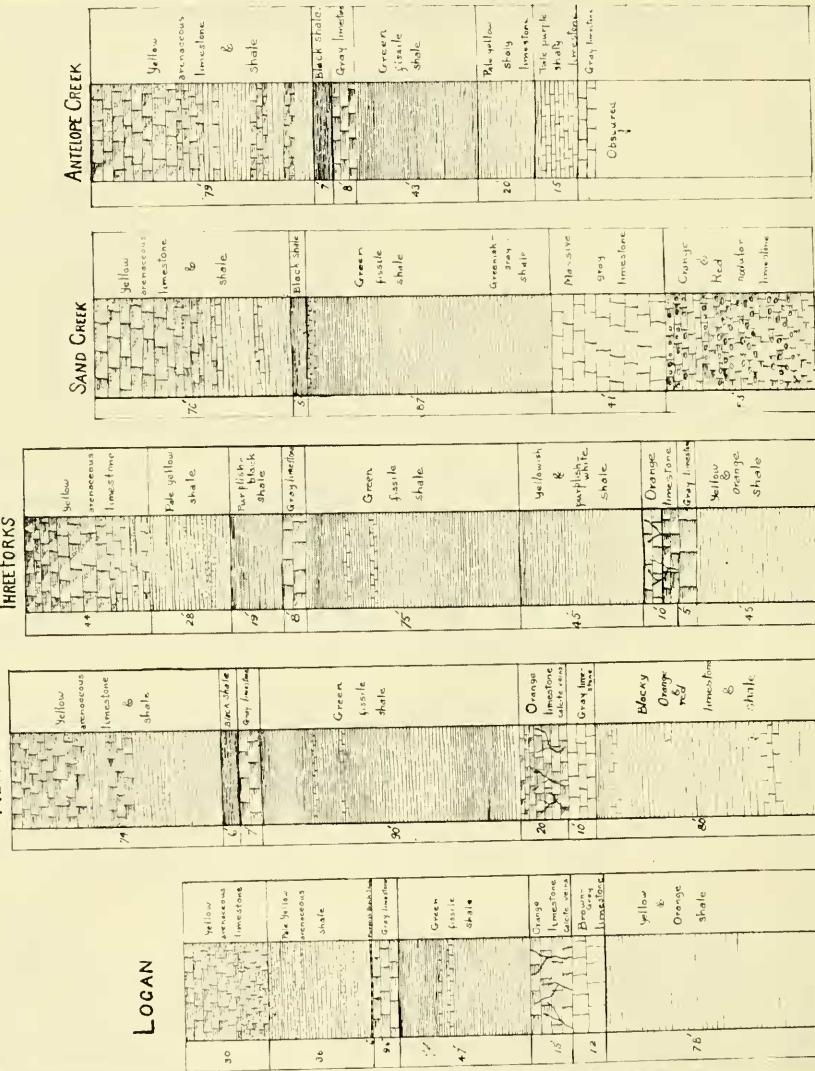
REKAP

THREE FORKS

ANTELOPE CREEK

SAND CREEK

LOGAN



IN PENCILS, DEC.

Columnar sections of the Three Forks formation.

comparison of the thickness of any of the members in different parts of the region can easily be made by referring to the numbers. It is noticeable that in all of these sections the thickness of the formation is considerably greater than in the section given by Dr. Peale, which has been generally taken as the standard for the Three Forks Formation.

For purposes of general comparative study the five columnar sections on Plate IV have been drawn. These sections are arranged in order from left to right, from the northeastern part of the region to the southwestern.

Throughout all of the region where the Three Forks Formation has been recognized it is almost invariably exposed in a small valley. This is due to the fact that it is prevailingly a shaly formation occurring between two massively bedded limestone formations, and differential erosion has produced the characteristic valley between the Jefferson and Madison limestone ridges. Because the formation generally occurs in a valley the exposures are obscured and the contacts masked by talus and vegetation. Often the valleys were traversed by the writer for several miles without finding any place where a satisfactory section could be measured. In consequence of this many of the sections are incomplete, especially in the lower part, but since no fossils have been found in the two lower members it is not so important that they should be included in the sections. The figures which are given were obtained by measurements with a steel-wire tape and the thicknesses were either measured directly or computed from the horizontal distance and the angle of dip.

The details of the various sections of the Three Forks Formation studied by the writer will now be considered in order from north to south.

Section A.—The most northerly occurrence of the formation was observed about four miles east of Lombard and one and one-half miles northeast of Crane, a flag station on the Chicago, Milwaukee, and Puget Sound Railway. Here there is a good exposure in a saddle, back of a cliff of the massive brown Jefferson limestone. The strata have a strike of about N. 70° E. and dip 15° north. The Lower shale member is almost entirely obscured by vegetation and only a small amount of reddish yellow angular shaly fragments in some gullies indicates its presence. The intermediate limestone member is of a rather bright yellow color and contains some white calcite veins. Above the limestone, which is about fifteen feet thick, there is a good

exposure of the very fissile green shale member. The green shale is from sixty to seventy feet thick and contains numerous bands of greenish and grayish limestone concretions, which are usually very fossiliferous. From many horizons in the lower forty feet of the green shale, pyritized fossils, chiefly cephalopods, often beautifully preserved, weather out on the surface and furnish excellent collecting. Above the green shale at this locality is about ten feet of very fossiliferous gray limestone which weathers reddish on the surface. Overlying this limestone are thirty or forty feet of yellowish shales, grading upward into calcareous sandstones. Above the yellow sandstones is the gray Madison limestone with fossils of Mississippian age. This section northeast of Crane was not measured carefully with a tape, because many of the contacts were obscured by talus or vegetation. However, enough of the section was exposed to show that it closely resembles the sections to the south at Rekap and Logan.

Section B.—The section next south of Lombard is near Rekap Station on the Northern Pacific Railway. The strata here strike N. 30°–35° E. and dip 30° W. The section was measured from the base of the gray Madison to the top of the brown Jefferson limestone and includes the following seven members:

1 and 2. Yellow sandy limestone and shale.....	74 feet.
3. Black coaly shale.....	6 "
4. Nodular gray limestone.....	7 "
5. Fissile green shale	}
and	
6. Gray and orange limestone. }	120 "
7. Pebbly yellow and reddish limestones and shales.....	<u>80</u> "
Total.....	287 feet.

The Three Forks formation was measured at two localities near Logan, Montana. One section was near the Gallatin River and the other was about two miles inland. The strata here strike about N. 50° E. and dip 40°–50° W.

Section C, measured near the Gallatin River, is as follows:

Base of gray Madison limestone.

1. Yellow arenaceous limestone.....	30 feet.
2. Pale yellow arenaceous shale.....	30 "
3. Purple fissile shale.....	.5 "
4. Bluish gray nodular limestone.....	9.5 "
5. Fissile green shale.....	47 "
6. Yellow crystalline limestone with calcite veins.....	15 "
Massive grayish brown limestone.....	12 "
7. Yellow and orange blocky shales.....	<u>78</u> "
Total.....	222 feet.

Section D, measured two miles farther north is as follows:

Base of gray Madison limestone.	
1. Yellow sandstone with some shale.....	44 feet.
2. Yellow shaly limestone.....	15 "
2a. Yellow argillaceous shale.....	5.5 "
3. Purplish red shale.....	1 "
4. Nodular gray limestone.....	8 "
5. Green shale.....	49 "
6. Orange limestone	}
and	
7. Reddish yellow shales mostly obscured	130 "
Top of Jefferson limestone.	
Total.....	252.5 feet.

The region north of Three Forks and west of the Missouri River has many good exposures of the Three Forks Formation. The valleys eroded in the formation have a general north to south direction and are nearly parallel with one another. The repetition of the formation is due partly to folding and partly to faulting. The structure in the central part of the ridge is that of a southward pitching anticlinal fold which is overturned to the east. A very large valley is eroded in the Three Forks formation in the western limb of the fold. The strata here strike N. 10° E. and dip 30° W. The following section was measured on the western side of this valley across the upper part of Three Forks Formation.

Section E:

Base of gray Madison limestone.	
1 and 2. Yellow sandstone and shale.....	75 feet.
3 and 4. Purplish shale with limestone at the base.....	20 "
5. Fissile green shale with layers of limestone concretions.	
Lower part of section obscured.	

West of the overthrust fault there is another valley formed in the Three Forks Formation. The strata here strike N. 20°-30° E. and dip 30°-40° W. The best exposures were seen on the western side of the valley in the small tributary gullies which cut across the dip of the strata. Partial sections were measured along this valley at several places in a distance of over two miles. These sections, beginning at the northern end of the valley, are as follows:

Section F, on tributary gully 3, western side of valley.

Base of yellow shale No. 2.	
3. Purplish black shale weathering reddish.....	13.5 feet.
4. Gray limestone.....	5 "
Top of green shale No. 5.	

Section G, on tributary gully 4, western side of valley.

Base of gray Madison limestone.

1. Yellow sandy limestone	44 feet.
2. Finely laminated pale yellow arenaceous shale, lower five feet drab colored and argillaceous	28 "
3. Fissile purplish black shale	19 "
4. Gray limestone	8 "
5a. Finely laminated green shales	75 "
5b. Yellowish and purplish white shale	45 "
6. Yellow limestone with calcite veins	15 "
7. Reddish yellow shales	45 "
Total	279 feet.

Section H, between tributary gullies 4 and 5 on the western side of the valley.

Base of yellow shale No. 2.

3. Purplish black coaly shale	15.3 feet.
Top of limestone No. 4.	

Section I, on fifth gully on western side of valley.

Base of gray Madison limestone.

1. Yellow sandy limestone, }	93 feet.
2. Yellow shales, }	
3. Purplish shales, }	
4. Gray limestone, }	
5. Green finely laminated shales	77 feet.
5a. Purple and yellow soft argillaceous shales	51 "
6. Yellow limestone with calcite veins.	

Lower part of section obscured.

Section J, at the southern end of this western Three Forks valley. Here the strata have a strike of about N. 40° E. and a dip of 20° W.

Base of gray Madison limestone.

1. Yellow sandstone	17 feet.
2. Laminated yellow shale	10 "
2a. Yellowish white limestone	2.5 "
3. Purplish gray shale	5 "
4. Gray nodular limestone	3 "
5. Fissile green shales	54 "
5a. Whitish yellow argillaceous shales	14 "
(Dr. Raymond's white blocky shale?)	
5b. Finely laminated yellowish green and locally reddish shale	7 "
(Dr. Raymond's red shale?)	
Top of Orange limestone No. 6.	

The following sections of the Three Forks Formation were measured by the writer south of Jefferson River between Willow and Antelope Creeks.

Section K, measured one and one-half miles west of Willow Creek. Here the strata are vertical and have an east-west strike.

Base of gray Madison limestone.	
1 and 2. Yellow sandstone and shales	70 feet.
3. Black coaly shale	5 "
4 and 5. Green shale calcareous at the top, with white and yellowish shales at the base	87 "
6. Massive gray limestone	41 "
7. Yellow nodular limestone	<u>53</u> "
Total	256 feet.
Top of brown Jefferson limestone.	

Section L, farther west in Three Forks ravine. Strike of strata N. 80° W. dip 70° N.

Base of gray Madison limestone.	
1. Yellow sandstone and talus obscuring 2, 3, 4, 5	108 feet.
6. Gray massive limestone	15 "
7. Yellowish red thinly bedded limestone	25 "
7a. Nodular red limestone, nodules 2 to 3 inches in diameter	<u>73</u> "
Total	221 feet.

Section M was measured just east of Sand Creek. The strata strike N. 60° E. and dip 40° N.

Base of gray Madison limestone.	
1. Yellow sandstone in cliff	10 feet.
2, 3, 4, and 5. Contacts obscured and therefore not measured separately	135 "
5a. Thinly bedded white and yellowish limestone	18 "
5b. Pale pink shaly limestone	12 "
Top of grayish yellow limestone No. 6.	

Section N, measured about a half miles west of Sand Creek.

Base of gray Madison limestone.	
1 and 2. Yellow arenaceous limestone and nodular yellowish gray limestone	76 feet.
3. Black coaly shale	5 "
4. Gray nodular limestone.	
Remainder of section obscured.	

Section O, the westernmost section, was measured about a quarter of a mile east of Antelope Creek. Strike E.-W., dip 30° N.

Base of gray Madison limestone.

1 and 2. Yellow sandy limestone and shale.	79 feet.
3. Black coaly shale.	7 "
4. Gray nodular limestone.	8 "
5. Green fissile shale.	43 "
5a. White thinly bedded limestone partly stained with limonite	20 "
5b. Purplish white thinly bedded limestone.	
Remainder of section obscured.	

This completes the list of measured sections of the Three Forks Formation in the northern part of the quadrangle and the neighboring region to the north. A comparison of these sections shows the persistence of all of seven members in all parts of the region. The members show in the different sections a considerable variation which may be briefly summarized as follows:

Members 1 and 2 together vary from 60–80 feet and have an average thickness of about 70 feet. Member 3 varies in thickness from about 19 feet, in the west Three Forks valley, to 6 inches at Logan. It has an average thickness of about 6 feet. Member 4 varies from 3 to 10 feet in thickness; member 5 from 50 to 120 feet; member 6 from 15 to 40 feet, and member 7 varies from 40 to 80 feet.

These thicknesses of members 1 and 6 are much greater than those given by Dr. Peale in his section for the formation. Dr. Peale's figures have apparently been adopted by Dr. Kindle² in his section at Logan, Mont., and also by Dr. Raymond,³ who, although he did not measure the section here or north of Three Forks, noted the presence of (1) a Lower Red-Shale zone; (2) a Green-Shale zone, and (3) a White Blocky Shale, all part of Dr. Peale's Green Shales. The writer has noted in Section J the probable position and thickness of these zones as recognized by Dr. Raymond. Although these zones are indicated in Sections G and I "farther north" and in Sections M and O south of the Jefferson River, they are generally not clearly defined and therefore are not given a place among the seven members of the formation as recognized by the writer.

The slight thickness of the yellow sandstone and shales of members 1 and 2, noted in Section J, is probably partly due to obscured contacts, and somewhat to actual thinning of the strata. Some deformation in the strata due to the folding and overthrusting may also be the cause of the lessened thicknesses of the members in this section.

² Kindle, E. M., *Bull. Am. Pal.*, No. 20, p. 8, 1908.

³ Raymond, P. E. *Amer. Jour. Sci.*, Ser. IV, vol. XXIII, pp. 116–122, 1907.

A comparison of all of the sections shows a distinct increase to the southwest in the amount of limestone in the formation. This is due chiefly to the increase in thickness of member 6 and the predominance of limestone in member 7. Thus there is a gradation toward the conditions which prevail in the southern part of the quadrangle.

Fossils were obtained from the upper part of the formation at all of the localities where sections were measured. The fossiliferous members of the formation are numbers 1, 2, 4, and 5. Fossils are particularly abundant in number 4, the gray limestone, and number 5, the green shale. The fossils in numbers 4 and 5 indicate an Upper Devonian age, and those in 1 and 2 indicate a transition into the Mississippian. The evidence for the age of the formation will be given with the description of the fossils.

The sections of the Three Forks Formation studied by the writer in the southern part of the Three Forks quadrangle are not as satisfactory as those just given on account of the much poorer exposures. The country here is much more mountainous, and the shaly beds are obscured by talus and vegetation. No fossils were obtained from the formation here, but this was probably due to insufficient search and poor exposures, because fossils have been found in small numbers in the formation in the northwest corner of the Yellowstone Park, which adjoins the Three Forks quadrangle on the southeast.

The best section measured by the writer in the southern part of the Three Forks quadrangle is located in the upper end of the West Gallatin Canyon where it opens out into the Lower Basin. Here the strata are downfaulted against the gneiss along a nearly vertical fault plane. The strata strike about N. 40° W., nearly parallel with the fault, and dip about 50° S. The thicknesses of the beds considered to belong to the Three Forks Formation are as follows:

Base of gray Madison limestone.	
Gray shaly limestone weathering buff, in lower part red and yellow	125 ± feet.
Brown limestone, breaking into small joint blocks	25 "
Yellowish red shaly limestone	40 "
Grayish brown limestone breccia	15 "
Obscured by talus	<u>35</u> "
Total	240 ± feet.
Brown Jefferson limestone with <i>Favosites cf. limitaris</i> .	

It will be noticed that although the seven members which compose the formation in the northern part of the quadrangle cannot be re-



cognized here there is a general persistence of a lower and upper shaly member separated by a more massive limestone. There are, however, no true argillaceous shales in the formation, as exposed in the southern part of the quadrangle.

Some of the sections of the Three Forks Formation measured by Dr. Weed⁴ in the northwest corner of the Yellowstone Park are similar in lithologic character to the section already given. Three of these sections are as follows:

Crowfoot Ridge Section.

Buff and red fissile argillaceous and siliceous limestone . . .	30 feet.
Crystalline magnesian limestone, generally dense and massive	50 "
Limestone, impure and argillaceous, in alternating thin fissile, and massive gray beds	<u>100</u> "
Total	180 feet.

Antler Peak Section.

Light gray limestone, somewhat massive	40 feet.
Dark brownish gray arenaceous limestone	<u>130</u> "
Total	170 feet.

Bighorn Pass Section.

Gray crystalline limestone	80 ± feet.
Dark bluish gray massive argillaceous limestone	20 "
Alternating beds of massive gray arenaceous limestone and fissile light gray limestone	<u>40</u> "
Total	140 ± feet.

East of the Yellowstone Park in the region described in the Absaroka folio of Central Wyoming, Dr. Weed⁵ has identified the Three Forks Formation, which there has an average thickness of about 250 feet. He describes the formation as consisting of bluish gray limestone at the base, alternating with shaly beds and fine clays. These pass upward into bedded limestones generally bright purple and blue, with intercalated thin layers of indurated earthy and sandy material. Recurring alternations abound, but limestone is the prevailing rock. In places near the top of the formation the shaly beds exhibit bright red and orange tints. Localities yielding small groupings of a marine Devonian fauna occur at several places in the Absaroka district.

The Three Forks Formation has been recognized by Dr. Kindle⁶ in

⁴ Weed, W. H., *Mono.*, 32, pt. 2, pp. 7, 22, and 26, 1899.

⁵ Weed, W. H., *Atlas Folio*, U. S. G. S., No. 52, 1899.

⁶ Kindle, E. M., *Bull. Am. Pal.*, No. 20, p. 12, 1908.

a section measured by him in southwestern Wyoming, on Labarge Mountain, northeast of the town of Viola. Here he notes the presence of 80 feet of drab shales and shaly, thin-bedded magnesian and siliceous limestone, barren of fossils, occurring below dark gray Madison limestone and above the Jefferson limestone.

The southernmost occurrence of the Three Forks Formation, which the writer has seen recorded, is in a section near Bear Lake in northern Utah in the Randolph quadrangle. Mr. Richardson⁷ reports the presence of 200 feet of soft reddish shaly limestone, which is poorly exposed, occurring between the Jefferson and Madison limestones. He considers this the equivalent of the Three Forks Formation farther north.

North of the Yellowstone Park the Three Forks Formation has been recognized in the Livingstone, Little Belt Mts., and Fort Benton Quadrangles. In the Livingstone quadrangle⁸ it is described as a series of thinly bedded, impure limestones, alternating with thin beds of shale, with a total thickness of about 250 feet. The top beds are often purple and red in color. The lower strata are earthy shales in beds a few feet thick, alternating with limestone layers of equal thickness.

In the Little Belt Mountains Quadrangle⁹ the upper member of the Monarch formation is equivalent to the Three Forks formation of other quadrangles. It consists of thinly bedded shaly limestones (with much argillaceous matter), of a bluish gray color when fresh, but weathering to a straw-yellow or pink color. The thickness is usually 40 or 50 feet and does not exceed 140 feet.

In the Fort Benton quadrangle¹⁰ the upper 30 feet of the Monarch Formation is equivalent to the Three Forks Formation, and consists of reddish shaly limestone with abundant Devonian fossils. This is as far north as the Three Forks Formation has been recognized so far as the writer can ascertain.

Northwest of Three Forks the Formation has been recognized in the Helena District by Dr. Knopf¹¹ who describes the section as follows:

Fine-grained black carbonaceous shales	15 feet.
Light-colored fossiliferous calcareous shales, grading downward into earthy shales with interbedded quartzite	270 feet.
Total	285 feet.

⁷ Richardson, G. B., *Amer. Jour. Sci.*, Ser. IV, Vol. XXXVI, pp. 406-416, 1913.

⁸ Atlas Folio, U. S. G. S., No. 1.

⁹ Atlas Folio, U. S. G. S., No. 56.

¹⁰ Atlas Folio, U. S. G. S., No. 55.

¹¹ Knopf, A., *Bull. U. S. G. S.*, No. 527, p. 92, 1914.

Another section is as follows:

Black shale.....	56 feet.
Calcareous argillite.....	136 "
Shale.....	<u>40</u> "
Total.....	232 feet.

Farther west, in the Philipsburg Quadrangle,¹² the Three Forks Formation is apparently absent, and the Jefferson limestone is immediately overlain by the Madison limestone. In the Camp Creek section near Melrose, about 50 miles southwest of Three Forks, Dr. Kindle¹³ maintains that the Three Forks Formation is represented by a bluish gray argillaceous shale and buffish shale in the lower part, with limestone bands near the middle, having a total thickness of about 200 feet.

The boundaries of the region throughout which the Three Forks Formation has been recognized may tentatively be placed at latitudes 48° and 42° north and longitudes 109° and 113° west. This includes a region with a north-south dimension of about 400 miles and an east-west dimension of 200 miles. It is very evident from these figures that the Three Forks Formation has not nearly so widespread a distribution as the Jefferson limestone, which underlies it, or the Madison limestone, which overlies it.

Although the Three Forks Formation has not been recognized by its lithological characters outside of the region just noted, it is likely from faunal evidence that the sea, in which the Three Forks Formation was deposited, covered an area much greater than that in which the formation has been recognized. The similarity of some of the fauna of the lower part of the Ouray limestone of Colorado with the brachiopod fauna of the Three Forks Formation indicates a connection in that direction, and the presence of a small Ouray faunule from the beds transitional from the Lower Banff limestone to the Lower Banff shale, reported by Dr. Shimer¹⁴ in the Lake Minnewanka section in Alberta indicates a spreading of this Upper Devonian sea to the north.

THE FAUNA OF THE THREE FORKS FORMATION.

The writer has made a careful study of the collection of fossils made by Dr. Raymond for the Carnegie Museum and also of his own col-

¹² Calkins, F. C., Prof. Pap. U. S. G. S., No. 78, p. 65, 1913.

¹³ Kindle, E. M., *Bull. Amer. Pal.*, No. 20, p. 9, 1908.

¹⁴ Shimer, H. W., *Bull. Geol. Soc. Am.*, Vol. XXIV, pp. 233-240, 1913.

FAUNAL LIST OF THE THREE FORKS FORMATION.

	5			4	2	1
	L.	M.	U.			
BRACHIOPODA.						
Atremata.						
<i>Lingula hubbardi</i> sp. nov.		R	R			
<i>L. alba-pinensis?</i> Walcott	R					
<i>L. cf. læna</i> Hall	R					
<i>L. sp. nov.?</i>	r					
Neotremata.						
<i>Orbiculoidea lodiensis</i> (Vanuxem)		R				
<i>Orbiculoidea sp.?</i>		R				
Telotremata.						
<i>Spirifer raymondi</i> sp. nov.	r	c	c	r		
<i>S. whitneyi</i> Hall		r	r	r		
<i>S. whitneyi</i> var. <i>monticola</i> var. nov.	r	C	C	C		
<i>S. whitneyi</i> var. <i>animasensis</i> (Girty)		r	r	r		
<i>S. whitneyi</i> var. <i>gallatinensis</i> var. nov.		r	r	r		
<i>S. cf. cuspidatus</i> Meek						c
<i>S. cf. newberryi</i> Hall						c
<i>S. cf. subequalis</i> Hall						c
<i>Syringothyris carteri</i> Hall					c	C
<i>Ambocalia gregaria</i> Hall		C	C	c		
<i>Leiorhynchus dunbarensis</i> sp. nov.			r	r		
<i>L. madisonense</i> sp. nov.		C	C	c		
<i>L. madisonense</i> var. <i>gibbosum</i> var. nov.		C	C	c		
<i>L. utahense</i> var. <i>ventricosum</i> var. nov.			c	c		
<i>L. jeffersonense</i> sp. nov.			r	r		
<i>L. mesacostale?</i> Hall	c	C	C	c		
<i>L. cf. laura</i> (Billings)		R	R			
<i>Camarotoechia contracta</i> Hall	c	C	C	C		
<i>C. metallica?</i> (White)?						c
<i>Cleiothyridina devonica</i> Raymond	c	C	C	C		
<i>C. sublamellosa?</i>					R	R
<i>Meristella barrisi</i> Hall		r				
Protremata.						
<i>Schizophoria striatula</i> var. <i>australis</i> Kindle		C	C	c		
<i>Rhipidomella vanuxemi</i> Hall				c	C	
<i>Schuchertella chemungensis</i> var. <i>arctostriata</i> (Hall)		c	c	C		
<i>S. crenistria</i> (Phillips?)						c
<i>S. inflata</i> (White & Whitfield)					r	C
<i>Productella coloradensis</i> Kindle		C	C	c		
<i>P. coloradensis</i> var. <i>plicata</i> Kindle		R	R			
<i>P. laminata</i> Kindle		c	c			
<i>P. spinigera</i> Kindle		C	C	c		
<i>P. cf. depressa</i> Kindle			r			
<i>P. cf. hirsuta</i> Hall		C	c			
<i>P. cf. hirsutiformis?</i> Walcott		R				
<i>P. cf. subaculeata</i> Walcott		c	c	c		
<i>P. subalata?</i> Hall		r				
<i>P. cf. arctirostrata</i> Hall				c	c	c

FAUNAL LIST OF THE THREE FORKS FORMATION.—Continued.

	5			4	2	1
	L.	M.	U.			
MOLLUSCA.						
Pelecypoda.						
<i>Lyriopecten fasciatus</i> Hall.		C	C	r		
<i>L. cf. solox</i> Hall.		R				
<i>L. cf. polydorus</i> Hall.		R				
<i>L. sp. nov.?</i>		C	C			
<i>Crenipecten amplus</i> Hall.		r	r			
<i>C. glaber</i> Hall.		R	R			
<i>Aviculopecten fasciculatus</i> Hall.		R				
<i>A. cf. celsus</i> Hall.		R				
<i>A. cf. princeps</i> Hall.		R				
<i>Aviculopecten</i> sp.?		R				
<i>Pterinopecten imbecilis</i> Hall.		R				
<i>P. vertumnus</i> Hall.		R				
<i>Pterinopecten</i> sp.?		R				
<i>Actinopteria boydi</i> Hall.		R				
<i>A. æmiliana?</i> = <i>Avicula æmiliana</i> Frech.		R				
<i>Actinopteria</i> sp.?		R				
<i>Loxopteria holzapfeli</i> Raymond.	c	c				
<i>Loxopteria clarkei</i> Raymond.	R	R				
<i>Leptodesma sociale?</i> Hall.		R				
<i>Leptodesma</i> sp.?		r				
<i>Glyptodesma cf. erectum</i> Hall.				R		
<i>Mytilarca chemungensis?</i> Conrad.		r				
<i>Modiomorpha</i> sp.?		c	c	c		
<i>Nucula</i> sp.?	c	c	c	c		
<i>Grammysia subarcuata</i> Hall.				r		
<i>Grammysia</i> sp.?	c	c	c	c		
<i>Goniophora cf. hamiltonensis</i> Hall.		c	c	c		
<i>G. cf. subrecta</i> Hall.	c	c	c			
<i>Palæanatina</i> sp.?		r				
<i>Leda</i> sp.?		R				
<i>Schizodus cf. appressus</i> Hall.		R				
<i>Cf. Edmondia philipi</i> Hall.		R				
<i>Macrodon chemungensis</i> Hall.		c	c	c		
<i>Phonia cf. cylindrica</i> Hall.		R				
<i>Cf. Palæoneilo brevis</i> Hall.		R				
<i>Spathella cf. typica</i> Hall.		R				
<i>Paracyclas</i> sp.?		r				
<i>Cypricardella</i> sp.?		R				
<i>Cypricardinia</i> sp.?		r	r			
Gastropoda.						
<i>Phanerotinus</i> sp.?				r		
Conularida.						
<i>Conularia</i> sp.?			r	r		
Nautiloidea.						
<i>Orthoceras montanense</i> Raymond.	c	c				
<i>Geisonoceras normale</i> Raymond.	c	c				
<i>G. accelerans</i> Raymond.	r	r				

FAUNAL LIST OF THE THREE FORKS FORMATION.—*Concluded.*

	5			4	2	1
	L.	M.	U.			
Ammonoidea.						
<i>Platyclymenia americana</i> Raymond	C	C	C			
<i>Platyclymenia polypleura</i> Raymond	C	C				
<i>Prolobites simplex</i> Raymond	C	C				
<i>Tornoceras crebriseptum</i> Raymond	C	C				
<i>T. douglassi</i> Raymond	r	r				
Crinoid stems	C	C	C			
Bryozoa, cf. <i>Edriotrypa</i> sp.?		C	C			

lection made for the Museum of Comparative Zoology. In the faunal list compiled by the writer, which immediately follows, only the species identified by him are included, and their comparative abundance and horizon are indicated by the letters *R* = very rare, *r* = rare, *c* = common, and *C* = very common, in the column with the number of the member in which they occur. The localities are not indicated on the faunal list because no difference was found in the fauna of the formation at the different localities. Most of the collecting was done at Logan and in the east and west valleys north of Three Forks, but enough specimens were collected from the other localities to show that the same species occur at the same horizons throughout this region.

This list of fossils identified by the writer from the Three Forks formation shows among other things (1) that the ammonoids are almost entirely limited to the lower and middle part of member 5, and (2) that members 1 and 2 contain a fauna which is different in most of its forms from that of the lower members, and is more like that of the Madison limestone which overlies member 1. The fauna of the yellow sandstone and shale is considered by Dr. Raymond¹⁵ to be transitional between the Lower Mississippian fauna of the Madison limestone and the Upper Devonian fauna of members 4 and 5 of the Three Forks Formation.

Dr. Schuchert¹⁶ has examined Dr. Raymond's specimens and notes the presence of *Syringothyris carteri* and *Spirifer* cf. *striatus*, and considers that this faunule is like that of the lower Louisiana limestone of Pike County, Missouri. He therefore concludes that there was a "break in deposition, clearly distinguishing the Devonian, both physically and faunally, from the Mississippian."

¹⁵ Raymond, *Am. Jour. of Sci.*, Ser. IV, Vol. XXIII, 1907, p. 119.

¹⁶ Schuchert, *Bull. Geol. Soc. Am.*, Vol. XX, 1910, p. 546.

The writer has made a careful study of these horizons in the field, and was unable to find any indication of unconformity in the section in this part, and concluded, that, although *Spirifer whitneyi* and other typical Upper Devonian forms present in 4 and 5 were not found in members 1 and 2, as noted by Dr. Raymond, certain forms, such as *Rhipidomella vanuxemi*(?) and *Productella cf. arctostriatus* were sufficiently abundant in both the gray limestone, number 4, and the yellow shale, number 2, which almost immediately overlies number 4 at Logan, where this careful study was made, to indicate that there is no sharp break in the record here. *Syringothyris carteri* was found in the yellow shale within six feet of the top of number 4, and in the same layers with *R. vanuxemi*(?). In the overlying yellow calcareous sandstone *S. carteri* is common, and is associated with *Schuchertella inflata* and *Productella cf. arctirostrata*, and certain doubtfully identified Spirifers. This faunule, although containing many lower Mississippian forms, is considered by the writer to be sufficiently different from the fauna in the overlying Madison limestone, which is regarded as Kinderhook, or basal Mississippian, to be considered transitional, as Dr. Raymond has suggested.

Syringothyris carteri is generally regarded as an index of Mississippian age, but this seems to be a case where it extends down as far as uppermost Devonian strata. Other species of *Syringothyris* have been reported from Middle or Upper Devonian strata in various parts of the Mississippi valley, and this genus is now regarded by Dr. Schuchert¹⁷ as having originated in the Cordilleran sea during later Devonian time.

The typical faunule of the Three Forks Formation, collected from members 4 and 5, is similar in certain of its forms to that of the lower Ouray limestone of Colorado and also to some of the Upper Devonian forms of the eastern United States. It compares closely with certain European faunules, especially those from near the Ural Mountains.

Dr. Th. Tschernyschew¹⁸ in 1887 made the following correlation of the Upper and Middle Devonian Formations of the Urals, Germany, and eastern North America:

¹⁷ Schuchert, *Am. Jour. Sci.*, Ser. IV, Vol. XXX, 1910, p. 223.

¹⁸ Tschernyschew, *Mem. Com. Geol., St. P.*, Vol. III, pp. 172-185, 1887.

	Ural.	Rhein.	North America.
Upper Devonian.	D.2/3 <i>Clymenia</i> Kalk.	<i>Clymenia</i> zone.	Chemung.
	D.1/3 Goniatites and Cuboides zone.	Goniatites zone. Cuboides zone.	Portage. Naples. Genesee.
Middle Devonian.	D.2/2 Sp. <i>annosofoi</i> and <i>Stringocephalus</i> .	Stringocephalus zone.	Hamilton group.

The Upper Devonian of the western border of the Ural Mountains is divided by Dr. Tschernyschew into two horizons. The upper horizon is correlated with the *Clymenia* horizon of Enkeberg, Fichtelgebirge, Saxony, Thüringerwald, and Cornwall, and is characterized by *Clymenia annulata*, *Clymenia flexuosa*, *Tornoceras simplex*, *Spirifer archiaci*, *Spirifer disjunctus*, *Rhynchonella acuminata*, *Camarophoria (Leiorhynchus) subreniformis*, *Orthis (Schizophoria) striatula*, etc. The lower zone is correlated with the Goniatites and Cuboides horizons of the Eifel and with the Naples fauna of eastern North America, and contains *Goniatites (Manticoceras) intumescens*, *Tornoceras simplex*, *Atrypa aspera*, *A. reticularis*, *Spirifer disjunctus*, *S. conoideus*, *Rhynchonella (Hypothyris) cuboides*, etc.

Dr. R. Wedekind¹⁹ has recently made a special study of the Upper Devonian stratigraphy of Germany, and has found that it can be subdivided by characteristic cephalopod faunas into six zones. These zones are named as follows, beginning with the uppermost: VI. Gonioclymenia, V. Lævigata, IV. Postprolobites, III. Prolobites, II. Cheiloceras, I. Manticoceras.

Dr. Wedekind has noted the wide distribution of the Prolobites zone IIIb, which he considers is represented by the Three Forks Formation of Montana. Although he does not include any of his other zones in his correlation with the Three Forks Formation, it seems likely that the Postprolobites zone is also represented, because *Clymenia annulata* of his zone IVb is closely related to *Platyclymenia americana* of the Three Forks Formation.

Dr. E. Perna²⁰ has recently correlated the Upper Devonian strata of the eastern Ural Mountains, with those of Westphalia (Enkeberg and Balve) and Silesia, and has shown that the upper horizon of Tschernyschew's classification can be divided into four zones, which

¹⁹ Wedekind, *K. Gesell. d. Wissen. zu Göttingen*, Mathematik-phys. Klasse, 1913.

²⁰ Perna, *ibid.*

are equivalent to the five upper zones of Dr. Wedekind's classification, and two lower zones, which are equivalent to the *Manticoceras* zone.

This sixfold division is not widely applicable and therefore is of little assistance in correlation with the American Upper Devonian formations, where the brachiopod fauna is much more abundant than the cephalopod fauna.

Apparently the cephalopods are the only abundant fossils in the German Upper Devonian, and for that reason the brachiopods are not mentioned. It is therefore possible to make a much closer correlation between the Upper Devonian of the Ural Mountains and North America, than between that of Germany and North America. From an examination of the brief lists of fossils, noted in connection with Tschernyschew's two zones of the Upper Devonian, it is evident that the upper zone, D², is approximately equivalent to the Three Forks Formation, exclusive of members 1 and 2, and contains many similar fossils, although only a few of the species are the same. This correlation and also the other European correlations place the Three Forks fauna above the *Manticoceras* fauna, and make it the latest Devonian fauna of which we have any record in North America, which is the conclusion at which Dr. Raymond²¹ arrived some years ago, before these recent European correlations were made.

DESCRIPTION OF THE BRACHIOPODA.

Class BRACHIOPODA.

Order ATREMATA Beecher.

Superfamily LINGULACEA Waagon.

Family LINGULIDÆ Gray.

Genus LINGULA Bruguiere.

1. *Lingula hubbardi* sp. nov. (Pl. VII, fig. 1.)

Description.—Shell elliptical, width about three-quarters the length; base regularly rounded; sides gently curving; apex obtuse, with an angle of about 115°. The shell has a narrow flattened border about one millimeter wide. The surface is marked by fine concentric striæ, also by fine radiating striæ on the middle portion. These striæ are somewhat wavy about two-thirds of the way from the apex to the margin. The substance of the shell is thin, glistening, brownish black,

²¹ Raymond, Proc. 7th Internat. Zool. Cong., Camb., Mass., 1910.

brittle material. The type specimen has a height of 18.5 mm. and a width of 14.5 mm., with the ratio of 1 : .79.

Locality.—A single very perfect valve was collected from the limestone in the green shale member (number 5) in the "east" valley, north of Three Forks. A somewhat smaller and less perfect specimen was collected by Dr. Raymond in 1903, from near this same locality. This type appears to be different from any figured species and so the writer has placed it in a new species which is named in honor of Mr. G. E. Hubbard, who found the specimen while aiding the writer in his geological work near Three Forks.

Order **NEOTREMATA** Beecher.

Family DISCINIDÆ Gray.

2. **Orbiculoidea lodiensis** (Vanuxem). (Plate VII, fig. 4.)

Orbiculoidea lodiensis VANUXEM, Geol. N. Y., Rept. 3d Dist., 1842, Pl. 163, fig. 1;

HALL, *Ibidem*, Rept. 4th Dist., 1843, p. 223, fig. 1.

Discina lodiensis WALCOTT, Mono. VIII, U. S. Geol. Surv., pp. 112-113, Pl. 2, fig. 5, 5a.

A few specimens from the middle of member number 5, collected by Dr. Raymond and the writer, were identified as *Orbiculoidea* sp. and one or two of the best preserved specimens were identified as *Orbiculoidea lodiensis* Vanuxem, on their general agreement with the description and figures of the Nevadan form from the White Pine Shale as noted by Dr. Walcott.

Order **TELOTREMATA** Beecher.

Family SPIRIFERIDÆ King.

Genus SPIRIFER Sowerby.

3. **Spirifer raymondi** sp. nov. (Pl. V, figs. 1-2; Pl. VI, figs. 12-13.)

Cf. Spirifer pinonensis, MEEK, King, 40th Parl. Surv., p. 45, Pl. 1, figs. 9a, b.

Cf. Spirifer pinonensis RAYMOND, Ann. Carnegie Mus., Vol. V, 1909, p. 143.

Cf. Spirifer argentarius KINDLE, Bull. Am. Pal., No. 20, 1908, p. 32, Pl. 2, fig. 4.

This form is apparently identical with the specimen figured by Dr. Raymond from the red shale as *Spirifer pinonensis*. About sixty specimens from the green shale and associated limestone were carefully studied by the writer, and they show marked differences from *S. pinonensis* as figured and described by Mr. Meek. These differences are as follows:

The shape of the shell is not semicircular in outline, but is triangular, and much like that of *S. mucronatus* Conrad. The cardinal margin terminates in acute and not rectangular or obtuse extremities. The proportions of height to width are different. *Spirifer pinonensis* has a ratio of .76 : 1 and a height of .92 in. and a width of 1.20 in. Six specimens of *Spirifer raymondi* were measured and gave the following dimensions: I. Height 12 mm.; width 25 mm.; ratio .48 : 1. II. Height 15 mm.; width 30 mm.; ratio .5 : 1. III. Height 11.5 mm.; width 21 mm. ratio, .54 : 1. IV. Height 13 mm.; width 23 mm.; ratio .56 : 1. V. Height 14 mm.; width 24 mm.; ratio .58 : 1. VI. Height 20 mm.; width 30 mm.; ratio .66 : 1.

Specimens of *S. pinonensis* have from eleven to fourteen rounded plications on each side of the mesial fold and sinus, and these plications are covered with radiating striæ. *Spirifer raymondi* has from nine to twelve rounded radiating plications on each side of the mesial fold and sinus, and in no specimen were more than twelve plications observed. No minute striations were seen on the plications of any of the specimens. All of the well-preserved specimens of *S. raymondi* show a slight fold in the middle of the sinus, and the surfaces of both valves are marked with rather fine undulating lines of growth.

Specimens from the Jefferson limestone near Princeton, Montana, have been by Dr. Kindle, referred for comparison to *Spirifer argentarius* Meek, which Dr. Schuchert believes to be the same as *S. pinonensis* Meek. The specimen figured by him is apparently identical with the average specimen of *Spirifer raymondi*.

Four specimens of the European species *Spirifer elegans* Stein, in the Museum of Comparative Zoölogy (Schultze's Collection) show a very marked resemblance to the specimens of *Spirifer raymondi*. The points of difference are that the specimens of *S. elegans* are one-third to one-half larger than *S. raymondi*, and the delthyrium in *S. elegans* is an equilateral triangle, while in *S. raymondi* its height is to its width as 1 : .6. The sinus in *S. elegans* is also somewhat broader and perfectly smooth.

On account of all of these differences from any described forms, it seems advisable to place these specimens from the Three Forks Formation under the new specific name *Spirifer raymondi*. This new species is named in honor of Dr. Raymond who collected the first specimens from Three Forks. The type is in the Carnegie Museum.

Locality.—Specimens of *Spirifer raymondi* are numerous in the

green shale and limestone bands of No. 5 at all of the localities where specimens were collected.

4. *Spirifer whitneyi* Hall. (Pl. V, fig. 5; Pl. VI, figs. 8-11. Cf. Pl. VIII, fig. 7.)

Spirifer whitneyi HALL, Geol. Surv. Iowa, pt. 2, 1858, p. 502, Pl. 4, fig. 2.

Spirifer whitneyi KINDLE, Bull. U. S. G. S., No. 391, 1909, p. 24.

A large number of specimens of spirifers with plicated fold and sinus were collected from the gray limestone, number 4, and the green shale, number 5, by Dr. Raymond, for the Carnegie Museum in 1905, and by the writer in 1912 and 1913 for the Museum of Comparative Zoölogy. These specimens have been carefully studied by the writer and compared with New York and European forms of *Spirifer disjunctus* Sowerby = *S. verneuili* Murchison, and also with specimens of *Spirifer whitneyi* from Lime Creek, Iowa. The results of this comparative study are as follows:

The specimens of *Spirifer disjunctus* from the Chemung formation of New York are similar to those of the de Koninck Collection from Sougniez Province, Liège, and from Colonster and Traipont. In general they are mucronate and rather large forms, with simple rounded plications. They are all very different from the specimens from Montana. Certain of the European forms identified as *Spirifer disjunctus*, from Boulonnais (Duval and de Koninck collections), are of the same shape and size as specimens of *Spirifer whitneyi* from Lime Creek, Iowa. The European specimens, however, all lack the fine striations on each plication which are characteristic of *Spirifer whitneyi*.

Some of the specimens from Montana have the same measurements and appearance as *Spirifer whitneyi* from Lime Creek, and in a few cases the surface is well enough preserved to show traces of fine striations on the plications. They have therefore been identified as *Spirifer whitneyi* Hall. A comparison of the measurements of the Boulonnais, Lime Creek, and Montana specimens is as follows:

Spirifer disjunctus Sow. from Boulonnais. Ratio (1), width on hinge line to height of brachial valve measured over the surface, from 1 : .53 to 1 : .71 majority of specimens 1 : .66. Ratio (2), width on hinge line to height of area: range 1 : .143 to 1 : .27, majority 1 : .21. Ratio (3), height to width of delthyrium; range 1 : .6 to 1 : 1, majority 1 : 1.



Spirifer whitneyi Hall. Lime Creek, Iowa.

Ratio (1), range 1 : .6 to 1 : .77. Ratio (2), range 1 : .23 to 1 : .24.
Ratio (3), range 1 : .86 to 1 : 1.

Spirifer whitneyi Hall. Three Forks, Montana.

Ratio (1), range 1 : .47 to 1 : .69. Ratio (2), range 1 : .17 to 1 : .27. Ratio (3), range 1 : .5 to 1 : .8. An average specimen from Three Forks has a width of 32 mm. a height of 21 mm., height of area of 7 mm., and width of delthyrium of 5.7 mm.

The number of plications on each side of the brachial valve and the number on the fold is as follows:

Spirifer disjunctus from Boulonnais, 18 to 31 on a side, majority 21; 9 to 13 bifurcating plications on the fold, majority of specimens have 11.

Spirifer whitneyi from Lime Creek, 16 to 26 on a side, and 7 to 12 on the fold.

Spirifer whitneyi from Three Forks, 16 to 26 on a side; majority 21; and 8 to 15 on the fold.

5. *Spirifer whitneyi* var. *animasensis* (Girty). (Plate V, figs. 11-13.)

Spirifer disjunctus var. *animasensis* GIRTY, Twentieth Ann. Rept. U. S. G. S., pt. 2, 1900, p. 48, Pl. 4, figs. 1-10.

Spirifer whitneyi var. *animasensis* (Kindle), U. S. G. S. Bull. 391, p. 25, Pl. 9, figs. 1-3.

About twenty of the spirifers from the Three Forks Formation have been identified by the writer as *Spirifer whitneyi* var. *animasensis* (Girty). These specimens are somewhat smaller than *Spirifer whitneyi* and they all show a relatively high area with frequently a slightly twisted ventral beak, and they compare well with the specimens figured by Drs. Girty and Kindle. The ratio of the width to the height of the brachial valve in the Montana specimens range from 1 : .5 to 1 : .76 and the ratios of width to height of area from 1 : .28 to 1 : .33. The ratios of the height to the width of the delthyrium range from 1 : .46 to 1 : 1. The ratios of the specimens of *Spirifer disjunctus* var. *animasensis* Girty are, width to height of area 1 : .23 to 1 : .36; height to width of delthyrium 1 : .75 to 1 : 1.

The specimens from the Three Forks Formation have from thirteen to twenty-one simple radiating plications on each side of the fold, and from nine to fourteen bifurcating plications on the fold. The presence of traces of striæ on some of the plications shows that this form is more

closely related to *S. whitneyi* than to *S. disjunctus*, as was pointed out by Dr. Kindle. The size of an average specimen from Montana is: width 30 mm.; height 19 mm.; height of area 9 mm.; width of delthyrium 5.5 mm.

6. *Spirifer whitneyi* var. *gallatinensis*, var. nov. (Pl. V, figs. 3-4;
Cf. Pl. VIII, fig. 12).

About twenty-five specimens of the same general form as those just described, show a very different type of area and on this account have been described as a new variety, *gallatinensis*. These specimens have a rather narrow area, which is usually flat, or only slightly curved, although the beak of the pedicle may be strongly incurved. The area is of equal width throughout its whole extent, and usually extends at right angles to the hinge-line. The area generally shows distinct fine vertical striæ.

The ratios of width to height of brachial valves range from 1 : .52 to 1 : .78. The ratios of width to height of area range from 1 : .125 to 1 : .2. The ratios of width to height of delthyrium range from 1 : .8 to .9 : 1. The size of an average individual is, width 29 mm.; height 19 mm.; height of area 4 mm.; width of delthyrium 4 mm. There are from sixteen to twenty-six plications on each side of the shell, and from nine to fifteen bifurcating plications on the fold. Some of the specimens show striations on the plications, and this and the general shape of the shell indicates a close relationship with *Spirifer whitneyi*. The type is in the Museum of Comparative Zoölogy.

Some of the specimens of *Spirifer disjunctus* from Europe (locality Try près Walfourt) show a type of area with parallel sides similar to *Spirifer whitneyi* var. *gallatinensis*. (Cf. Pl. VIII, fig. 12.) Ratios from the European specimens show a range in width to height of brachial valve from 1 : .4 to 1 : .56, and a range in width to height of area from 1 : .1 to 1 : .2, and a range in height to width of delthyrium from 1 : .62 to 1 : 1. None of these specimens show traces of striations on the plications.

This close resemblance between certain specimens of *Spirifer disjunctus* from Boulonnais, and *Spirifer whitneyi*, and certain specimens of *Spirifer disjunctus* from Try près Walfourt and *Spirifer whitneyi* var. *gallatinensis* shows that we have here a good example of parallel development in two very similar species of spirifers. Each species has developed similar variations in regard to the shape of the shell

and the area. In cases where the striations are preserved on the specimens from western America it is easy to refer them to the species *whitneyi*, but the majority of the specimens are exfoliated, and they therefore come within the limits of the species *disjunctus*. This is undoubtedly the reason why so many of the western American species of this general type have been identified as *Spirifer disjunctus*. The wide variations in the European specimens of *Spirifer disjunctus* = *Spirifer verneuili* show that varietal differences have been overlooked in the identification of the specimens.

7. *Spirifer whitneyi* var. **monticola**, var. nov. (Pl. V, figs. 6-10;
Pl. VI, figs. 1-7).

Cf. *Spirifer whitneyi* KINDLE, Bull. No. 391, U. S. G. S., p. 24, Pl. 8, figs. 2-5.

By far the commonest of the specimens of *Spirifer* from Montana is a robust form with a relatively short hinge-line. Several hundred specimens of this variety were collected by Dr. Raymond and the writer from all of the localities where the Three Forks Formation is well exposed. These specimens are apparently identical with those from the Ouray limestone of Colorado and New Mexico, which are figured by Dr. Kindle and identified as *Spirifer whitneyi*. Dr. Kindle notes the fact that the forms from Colorado and New Mexico are more robust and have flatter and broader plications than the Iowa specimens. He considers it undesirable to make a new species based on these differences, because *Spirifer disjunctus* is such a variable type.

A study of the large collection of specimens from the Three Forks formation has convinced the writer that these specimens show certain characters which are sufficiently distinct from *Spirifer whitneyi* to be the basis for a new variety, *monticola*.

A series of seven specimens (See Pl. VI) was selected to show variation in shape in the new variety. The ratios between the width and height of the brachial valves are as follows: (a) .84 : 1; (b) .88 : 1; (c) .93 : 1; (d) 1 : 1; (g) 1 : .97; (e) 1 : .81; (f) 1 : .78. The ratios of the width to the height of the area are as follows: (a) 1 : .152; (b) 1 : .227; (c) 1 : .232; (d) 1 : .3; (e) 1 : .325; (f) 1 : .345; (g) 1 : .39. It is interesting to note that with the exception of specimen, g, the increase in the height of the area and its flattening-out follows directly the increase in length of the hinge-line.

A comparison of these ratios with those of *Spirifer whitneyi* from Lime Creek show that all of the western specimens have a shorter

hinge-line and relatively higher brachial valve than the specimens from Iowa. Furthermore all the western specimens are more robust, and have a ratio between the length of hinge and the maximum thickness of the specimen which ranges from 1 : .86 to 1 : .54, while the same ratios for specimens of *Spirifer whitneyi* from Iowa range from 1 : .5 to 1 : .46.

A large percentage of the well-preserved specimens of *Spirifer whitneyi* var. *monticola*, show fine striæ on the rather broad, flattened, radiating plications. The plications vary in number from thirteen to twenty-nine on a side, and from nine to nineteen on the fold. The size of a moderately small individual is: width 22 mm., height 25 mm., height of area 5 mm., width of delthyrium .45 mm., thickness 19 mm. The measurements of a rather large individual are: width 37 mm., height 30 mm., height of area 12 mm., width of delthyrium 9.5 mm., thickness 26 mm. Specimens from the fissile green shales of number 5 are much better preserved than those from the limestone layers. Almost all of the specimens from the shale show the characteristic striations on the plications, and some show a tendency to develop alate, almost spiniform, hinge extremities.²² Such delicate spinose points are preserved in only a few of the specimens from the shale, so that it seems likely that this is an abnormal feature and not a general character.

About fifteen of the specimens, including Nos. 174 *a*, *b*, and *c*, of the series just mentioned, and specimens numbered 172*c* and *d*, and 176 *a* and *b*, show under the hand-lens, or microscope, a spinose-surface covering the plications. The character of this surface varies from numerous irregularly scattered small rounded spines,²³ as seen on specimens 172*d* or 174*a* to elongate spine bases arranged in radiating rows (See Pl. V, figs. 7, 8, 9,), which under slight magnification appear continuous, and therefore like the normal striæ. Upon a closer examination they appear to be an intermediate stage between the normally striated specimens and the irregularly spinose individuals. Since there is this gradation in surface character on specimens, which in other respects are identical, it seems best to note it merely as a variable detail in *Spirifer whitneyi* var. *monticola*. Specimens from the green shale almost always have the details of the surface well-preserved and it is from a study of these that the intermediate stages

²² See Plate V, fig. 6.

²³ See Plate V, fig. 10.

between the normally striate and the irregularly spinose types were made out. The type is in the Carnegie Museum.

Locality.—Specimens of *Spirifer whitneyi* and its varieties were obtained from the gray limestone, number 4, and the green shale number 5, at all of the localities studied in detail by the writer, where the Three Forks Formation is exposed in the region about Three Forks and to the north.

Genus AMBOCÆLIA Hall.

8. *Ambocœlia gregaria* Hall.

Ambocœlia gregaria HALL, 13th Ann. Rept. N. Y. State Cab. Nat. Nist., p. 81.

Ambocœlia gregaria RAYMOND, Ann. Carnegie Mus., Vol. V, 1909, p. 143.

Specimens referred to this species are very common in certain of the limestone bands in the green shale, number 5, particularly at Three Forks and Logan. The brachial valves show the well-marked sinus, which characterizes this species.

Locality.—Green shale, member number 5, at Three Forks, Logan, and localities to the north.

Family RHYNCHONELLIDÆ Gray.

Genus LEIORHYNCHUS Hall.

9. *Leiorhynchus dunbarensis* sp. nov. (Plate VIII, fig. 8.)

Cf. Leiorhynchus astabulense PROSSER, Ohio Geol. Surv., 4th ser., Bull. 15, 1913.

Shell very gibbous and wide in comparison with its height. The ventral valve is slightly convex and the beak rather prominent. The mesial sinus becomes very deep toward the margin and contains two rather low, rounded plications. The sinus is bordered by two large rounded plications, with usually two less elevated, rounded plications on either side, the outermost usually faintly defined. The dorsal valve is very convex and strongly incurved at the umbo, and rises somewhat above the ventral valve. The surface is marked by a high fold with three rather angular plications. The sides have one strongly marked plication next to the fold, and usually two less distinct, low, rounded plications nearer the lateral margins. The surface of the well-preserved specimens is covered with strong, concentric, imbricated growth-lines. The dimensions of the type specimen are: width 27 mm., height 16 mm. Another specimen has a width of 22 mm., and a height of 14 mm. The type is in the Carnegie Museum.

This species resembles *Leiorhynchus astabulense* Prosser in many

respects, but the ratio of width to height in *Leiorhynchus dunbarensis* is 1 : .6 instead of 1 : .9 as in *L. astabulense*, and the sides have fewer plications. The type is in the Carnegie Museum.

Locality.—Five specimens of this species were collected from the limestone layers at the top of member number 5, near Dunbar's mine, north of Three Forks. Three of them were collected by Dr. Raymond in 1905 and two of them by the writer in 1912. One very well preserved specimen was obtained by the writer in 1913 from the base of gray limestone number 4, from east of Lombard, Montana.

10. *Leiorhynchus madisonense* sp. nov. (Plate VII, figs. 11-13.)

Outline of shell oval; width always greater than height; the ratio varies from 1 : .64 to 1 : .76. An average specimen has a width of 19 mm. and a height of 14 mm., with a ratio of 1 : .73.

The pedicle valve curves to the sides and has a well marked, rather broad sinus, developed slightly above the middle of the shell. Beak small and closely incurved over the umbo of the opposite valve.

The brachial valve is much more convex than the pedicle, and rounds to the sides. Mesial fold well-developed in most cases, and greatly elevated at the outer border. Surface marked by fine imbricating concentric striæ, also by fine radiating striæ, which are well-developed on the sides of the shell. The sinus is generally characterized by two rounded plications, rarely one or three. The fold is usually marked by three, sometimes two, or four, plications. Sides of the shell usually marked by one or two faint, low, rounded plications. These plications all extend to the apex of the shell. The type is in the Carnegie Museum.

This species differs from *Leiorhynchus mesacostale* in the smaller number of plications in the fold and sinus, and in the greater width of the shell in relation to its height.

Locality.—Specimens are numerous in the green shale and associated limestone layers of member number 5, at Three Forks, Logan, and most of the other localities in the region near Three Forks.

11. *Leiorhynchus madisonense* var. *gibbosum* var. nov. (Plate VII, figs. 14-16.)

Cf. Leiorhynchus kellogi HALL, Pal. N. Y., Vol. IV, p. 361, Pl. 56.

Shell more gibbous and usually larger than *Leiorhynchus madisonense*. An average specimen has a width of 23 mm. and a height of 20 mm.,



with a ratio of width to height of 1 : .87. A smaller specimen has a width of 19 mm. and a height of 15 mm., and a ratio of 1 : .79. The range in the ratio of width to height is from 1 : .77 to 1 : .89.

The valve of the pedicle is gibbous a little below the umbo, and curves evenly to the sides. It becomes flattened in the middle and is deeply sinuate toward the front of the shell. The beak is closely incurved over the umbo of the brachial valve.

The brachial valve is more convex than the pedicle and curves to the sides, with a broad, flattened mesial fold, well-developed from the upper third of the shell.

The surface is marked by fine concentric striæ and also by fine radiating striæ, which are usually most prominent on the sides of the shell. From three to seven low, rounded plications occur in the sinus, and from four to eight in the fold. The specimens usually have from one to three low, rounded plications on the sides of the valves, which diminish in relief toward the lateral margins. All of the plications radiate from the beaks and they are almost invariably clearly defined from the beaks to the margin of the shell. This new variety differs from *Leiorhynchus madisonense* in the greater convexity of the valves; the normally greater number of plications in the fold and sinus, and in the height and width being more nearly equal.

This new variety differs from *Leiorhynchus kellogi* in the lesser number of plications on each side of the fold and sinus, and in having the plications extending all the way from the margin to the apex, instead of half-way or less, as in *L. kellogi*. The type is in the Carnegie Museum.

Locality.—Specimens are numerous in the gray limestone, number 4, and also in the green shales, number 5, at Three Forks, Logan, and the other localities in that region. Twenty-four specimens were collected by Dr. Raymond in 1905 and seventeen by the writer in 1912, and about ten in 1913.

12. *Leiorhynchus utahense* var. *ventricosum* var. nov. (Plate VIII, figs. 10-11.)

Cf. Leiorhynchus utahensis KINDLE, Bull. Am. Pal., No. 20, p. 27, Pl. 3, figs. 1-1c.

Cf. Leiorhynchus greencanum (ULRICH), Cont. Am. Pal., I, 1886, p. 26, Pl. 13, fig. 1.

Shell large, ventricose on brachial side, and flattened on side of pedicle. Ratio of width to height 1 : .94. Thickness usually somewhat less than height. The type specimen has a width of 37 mm.,

height 35 mm., and convexity 28 mm. The largest specimen obtained has a height of 47 mm., a width of 42 mm., and a convexity of 47 mm. This specimen has a ratio of width to height of .89 : 1, and a convexity equal to the height. The cardinal view of all of the specimens is sub-semicircular in outline.

Valve of pedicle gibbous at the umbo, flattened toward the sides, and deeply sinuate toward the front. Beak small, acute, and closely incurved over the umbo and brachial valve. Two low, rounded plications and three broad furrows are present in the sinus, which is scarcely defined at the umbo, but becomes broad and fairly deep at the anterior margin.

Brachial valve ventricose, with a well-defined low fold, consisting of three rather broadly rounded plications, the one in the middle somewhat narrower than the other two.

Surface of both valves marked by fine concentric lines, with more prominent uneven growth-wrinkles at increasingly frequent intervals toward the margin of the valves. The sides of the shell show distinct radiating striations, about four to one millimeter, and there are faint indications of them on the sinus and on a part of the fold.

This form is considered to be a variety of *Leiorhynchus utahense* Kindle, of the Jefferson limestone of Utah, from which it differs in its sub-semicircular and not sub-trigonal outline, and in its larger size, and lesser number of plications in the sinus and fold. The type is in the Carnegie Museum.

It differs from *Leiorhynchus greeneanum* (Ulrich) in its greater height in relation to its width; in having a sub-hemispherical rather than a sub-trigonal cardinal view, and in having the fold clearly marked to the anterior extremity of the valve, and containing three distinct plications, instead of two or three irregular, faint plications.

Leiorhynchus greeneanum is a younger form, and occurs in the Keokuk limestone of Indiana.

Locality.—Specimens of this new variety were collected from the base of limestone number 4, and the top of green shale number 5, chiefly from Three Forks and Logan. Dr. Raymond collected three specimens in 1905 and the writer collected six in 1912 and ten in 1913.

13. *Leiorhynchus jeffersonense* sp. nov. (Plate VIII, fig. 9.)

Shell large, sub-ovate and moderately convex on the brachial side; flattened on the pedicle side. Width of an average specimen 44 mm.;

height 28 mm.; ratio 1 : .635. Width of a smaller individual 38 mm.; height 23 mm.; ratio 1 : .6.

Valve of pedicle flattened toward the sides, with a moderately deep sinus, which starts from the beak. Sinus flat, and bordered by a single, usually prominent, rounded plication on each side. Four or five distinct, evenly spaced, rounded plications in the sinus, and on a few specimens one or two faint plications on the sides of the valve.

Brachial valve convex, with a prominent flat-topped fold, which starts from the beak, and is composed of five or six rounded plications. One or two very low plications are visible on the sides of the valve in a few specimens.

This species differs from *Leiorhynchus utahense* var. *ventricosum*, with which it is associated in the field, in its greater width in relation to its height; in the lesser convexity of the valves, and in the possession of a greater number of plications in the fold and sinus.

One specimen referred to this species was collected by Dr. Raymond in 1905, and eight specimens were collected by the writer in 1912 from the base of the gray limestone, number 4, and the upper limestone in green shale number 5, in the east and west valleys north of Three Forks. In 1913 two well-preserved specimens were obtained from this same horizon near Sappington, and a few were obtained from Logan, and Lombard. The type is in the Museum of Comparative Zoölogy.

14. *Leiorhynchus mesacostale* Hall.

Leiorhynchus mesacostalis HALL, 1867, Pal. N. Y., Vol. IV, p. 362, Pl. 67, figs. 18-25.

Leiorhynchus mesacostale RAYMOND, Ann. Carnegie Mus., Vol. V, No. 2, 3, 1909.

Fossils referred to this species are fairly common in the limestone and green shale of member number 5, at all of the localities. These are all rather small flattened forms, with the plications limited to the fold and sinus. There are usually three plications in the sinus and four in the fold, but the number is rather variable. They are all evenly spaced, and in that respect differ from *L. mesacostale* as figured by Hall. In general appearance they resemble *Camarophoria subreniformis* which is described by Tschernyschew from the Ural Mountains, but without material for comparison it is not possible to tell how closely these forms compare.

15. *Leiorhynchus cf. laura* (Billings).

Cf. Leiorhynchus multicastrata HALL, Pal. N. Y., IV, 1867, p. 358, Pl. 56, figs. 26-40.
Cf. Leiorhynchus clarkei PROSSER, Ohio Geol. Surv., 4th Ser. Bull. 15, 1913.

Several specimens from the green shale and limestone member, number 5, from Three Forks and Logan, are referred with some doubt to this species. They are small flattened shells with three or four low, rounded plications on each side of the sinus and fold, as well as in the sinus and fold. They compare closely with *L. multicastrata* as figured by Hall, but that is a Hamilton form, and these Montana specimens are in a higher horizon. The Montana specimens are also similar to *L. clarkei* Prosser, but are much smaller in size.

Genus CAMAROTÆCHIA Hall & Clarke.

16. *Camarotæchia contracta* Hall.

Rhynchonella (Stenocisma) contracta HALL, 1867, Pal. N. Y., IV., p. 351, Pl. 55, figs. 26-39.

Camarotæchia contracta? KINDLE, U. S. G. S. Bull. 391, p. 22, Pl. VI, figs. 1-2a.

Camarotæchia contracta RAYMOND, Ann. Carnegie Mus., Vol. V, 1909, p. 141.

Specimens apparently identical with those from Colorado and New Mexico, which are identified as *C. contracta*, occur as one of the most abundant forms in the green shale and limestone member number 5, and also in smaller numbers in the overlying gray limestone, at all of the localities where fossils were collected from the formation by the writer. The specimens vary greatly in the number of plications in the sinus and fold. The average number is three in the sinus and four in the fold, but a considerable number of specimens have more or less. The extreme numbers in the sinus are from two to five, and in the fold from three to six.

Family ATHYRIDÆ Phillips.

Genus CLEIOTHYRIDINA Buckman.

17. *Cleiothyridina devonica* Raymond.

Cleiothyridina devonica RAYMOND, Ann. Carnegie Museum, Vol. V, 1909, p. 143.

A very large number of specimens of this species were collected by the writer in 1912 and 1913 from the gray limestone number 4, and from the green shale and limestone member number 5, at all of the localities. This species is described in detail by Dr. Raymond from its occurrence at Three Forks and Logan.

Genus MERISTELLA Hall.

18. *Meristella barrisi* Hall. (Plate VII, fig. 2.)

Meristella barrisi HALL, Pal. N. Y., Vol. IV, 1867, p. 304, Pl. 49.

Meristella barrisi KINDLE, Bull. 391, U. S. G. S., p. 30, Pl. 9, figs. 7-9.

Four specimens identified by the writer as of this species, were collected from the limestone layers in the middle part of the green shale, number 5, from the west valley, north of Three Forks. They closely resemble the forms figured by Dr. Kindle from New Mexico, and also those figured by Hall from the state of New York.

Order PROTREMATA.

Superfamily STROPHOMENACEA Schuchert.

Family ORTHIDÆ Dalman.

Genus SCHIZOPHORIA King.

19. *Schizophoria striatula* var. *australis* Kindle. (Plate VIII, figs. 3-5.)

Schizophoria striatula var. *australis* KINDLE, U. S. G. S., Bull., 391, p. 21, Pl. 2, figs. 1 and 2.

About thirty specimens identified as this variety, were collected by the writer from the middle and upper part of member number 5 at Three Forks and Logan. The specimens are not as well preserved as those from New Mexico figured by Dr. Kindle, but they resemble them sufficiently closely to make the identification fairly certain.

Genus RHIPIDOMELLA Oehlert.

20. *Rhipidomella vanuxemi*(?) Hall. (Plate VIII, figs. 3-5.)

Orthis vanuxemi Hall, 1858, Geol. Surv. Iowa, I, pt. 2, p. 487, pl. 2, figs. 2 and 3.

A large number of specimens, identified as this species, were collected by Dr. Raymond and the writer from the top of the gray limestone, number 4, and the base of the yellow shale, number 2, chiefly at Logan. A few specimens were obtained from near Sappington and Rekap, and in the east and west valley at Three Forks. The specimens are all nearly circular in outline, and are very flat, with no sinus or fold, and the plications have numerous pores as in *R. vanuxemi*. This horizon is higher than that in which *R. vanuxemi* occurs in New York, but, because of the very close correspondence in shape and details, these forms from Montana are identified with some doubt as belonging to this species.

Family STROPHOMENIDÆ King.

Genus SCHUCHERTELLA.

21. *Schuchertella chemungensis* var. *arctostriata* (Hall). (Plate VII, fig. 6.)

Streptorhynchus chemungensis var. *arctostriata* HALL, Pal. N. Y., Vol. IV, Pl. 9, fig. 1.
Hemipronites chemungensis var. *arctostriata* MEEK, 40th Parl. Surv., Pl. 3, fig. 2.
Schuchertella chemungensis var. *arctostriata* (KINDLE), Bull. Am. Pal., No. 20, p. 26.
 Pl. 2.

About ten specimens, identified as this variety, were collected from the limestone bands in the green shale, number 5, in the valleys near Three Forks, and eight specimens were collected from the same horizon at Logan by Dr. Raymond in 1905 and by the writer in 1912 and 1913. One very well preserved specimen was obtained by the writer in 1913 from the gray limestone member near Sappington. These specimens show a considerable range in size, but they all seem to belong to the same species and variety. The dimensions of an average specimen are: width on hinge 25 mm., height 18 mm. A rather small specimen has a width of 9 mm. and a height of 7.5 mm. All of the specimens show the characters of the variety as noted by Hall. The surface is covered with close, crenulated, radiating striæ, increasing mainly by interstitial addition. The specimens appear to be identical with those figured by Dr. Kindle from the Jefferson limestone of Princeton and Livingston, Montana.

Family PRODUCTIDÆ Gray.

Genus PRODUCTELLA Hall.

22. *Productella spinigera* Kindle. (Plate VIII, fig. 3.)

Productella spinigera KINDLE, Bull. U. S. Geol. Surv., No. 391, p. 19, Pl. V, figs. 1-4.

About twenty-five specimens, identified as this species, were collected by Dr. Raymond and the writer from members numbers 4 and 5 at the various localities. These specimens show very little variation and correspond very well with the description and figures of the Ouray species of Dr. Kindle.

23. *Productella coloradensis* Kindle. (Plate VII, figs. 5 and 7-8.)

Productella coloradensis KINDLE, Bull. U. S. Geol. Surv., No. 391, p. 17, Pl. IV, figs. 2-8.

About thirty specimens collected by Dr. Raymond and the writer from members 4 and 5 were identified by the writer as this species.

24. *Productella coloradensis* var. *plicata* Kindle.

Productella coloradensis var. *plicatus* KINDLE, Bull. U. S. Geol. Surv., No. 391, p. 18, Pl. IV, figs. 9-12.

The writer obtained two well-preserved specimens from the upper portion of member number 5, north of Three Forks, which show the detailed characters of this variety.

25. *Productella laminata* Kindle. (Plate VIII, fig. 6.)

Productella laminatus KINDLE, Bull. U. S. Geol. Surv., No. 391, p. 18, Pl. IV, figs. 13-14.

About ten specimens from the upper portion of member number 5 in the collections of Dr. Raymond and the writer were identified as of this species.

26. *Productella* cf. *depressa* Kindle.

Productella depressa KINDLE, Bull. U. S. Geol. Surv., No. 391, p. 20, Pl. V, fig. 5, 5a.

Five specimens collected by Dr. Raymond from member number 5 are referred by the writer, with some doubt, to this species.

27. *Productella* cf. *arctirostrata* Hall.

Productella arctirostrata HALL, Pal. N. Y., Vol. IV, 1867, p. 182, pl. 26, figs. 16-23.

About thirty poorly preserved specimens from limestone member number 4, and the overlying yellow shale of number 2 are referred to this species with some doubt. Most of the specimens have continuous plications, rather than a row of elongate spine-bases as shown in most of the figures of this species.

The following rather unsatisfactory determinations of poorly preserved *Productellas* are merely listed here without comment. They are all from the upper part of member number 5 or from number 4.

Productella cf. *hirsuta* Hall, a rather common form.

Productella cf. *hirsutiformis* Walcott, a very rare form in the collections.

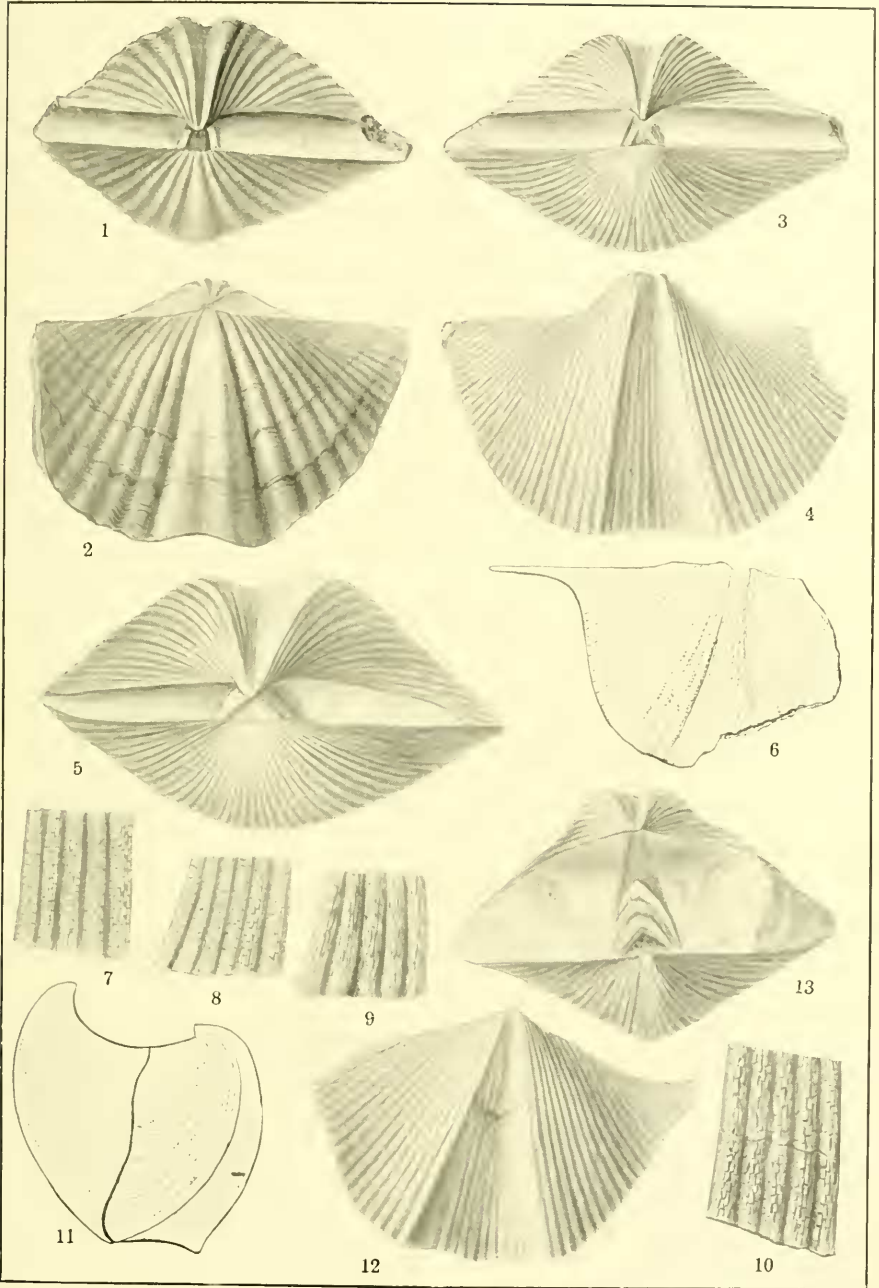
Productella cf. *subaculeata* Walcott, a rare form.

Productella cf. *subalata* Hall, a fairly abundant form.

This completes the description of the Brachiopoda from members numbers 4 and 5 of the Three Forks formation. A description of the Pelecypoda of the formation is in preparation for a later paper in this series.

EXPLANATION OF PLATE V.

- FIG. 1. *Spirifer raymondi* Haynes, sp. nov. (Top view showing shape of area.)
× 2.
- FIG. 2. *Spirifer raymondi* Haynes, sp. nov. × 2.
- FIG. 3. *Spirifer whitneyi* Hall, var. *gallatinensis* Haynes, var. nov. (Showing parallel-sided area.) × 2.
- FIG. 4. *Spirifer whitneyi* Hall, var. *gallatinensis* Haynes, var. nov. (Ventral valve of specimen shown in Fig. 3.) × 2.
- FIG. 5. *Spirifer whitneyi* Hall. × 2.
- FIG. 6. *Spirifer whitneyi* Hall, var. *monticola* Haynes, var. nov. (Showing spiniform cardinal angle.) × 2.
- FIG. 7. *Spirifer whitneyi* Hall, var. *monticola*. × 4. No. 176b.
- FIG. 8. *Spirifer whitneyi* Hall, var. *monticola*. × 4. No. 172b.
- FIG. 9. *Spirifer whitneyi* Hall, var. *monticola*. × 4. No. 172c.
- FIG. 10. *Spirifer whitneyi* Hall, var. *monticola*. × 4. No. 172d.
(Figs. 7 to 10 inclusive show details of surface markings.)
- FIG. 11. *Spirifer whitneyi* Hall, var. *animasensis* (Girty). (Side view.) × 2.
- FIG. 12. *Spirifer whitneyi* Hall, var. *animasensis* (Girty). (Ventral valve of specimen in Fig. 11.) × 2.
- FIG. 13. *Spirifer whitneyi* Hall, var. *animasensis* (Girty). (Top view showing high area of same specimen.) × 2.



Brachiopods from Green Shales. (See opposite page.)

EXPLANATION OF PLATE VI.

- FIG. 1. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174a.
 FIG. 2. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174b.
 FIG. 3. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174c.
 FIG. 4. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174d.
 FIG. 5. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174e.
 FIG. 6. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174f.
 FIG. 7. *Spirifer whitneyi* Hall, var. *monticola*. × 1. No. 174g.
 (Figs. 1 to 7 show variations from a long, narrow form to a short wide form, and also in height of area and length of hinge-line.)
- FIG. 8. *Spirifer whitneyi* Hall. × 2.
 FIG. 9. *Spirifer whitneyi* Hall. (Top view of specimen shown in Fig. 8.) × 2.
 FIG. 10. *Spirifer whitneyi* Hall. Lime Creek, Iowa. × 2.
 FIG. 11. *Spirifer whitneyi* Hall. Lime Creek, Iowa. (Top view of specimen shown in Fig. 10.) × 2.
 FIG. 12. *Spirifer raymondi* Haynes. Three Forks, Montana. (Ventral valve of extreme mucronate type.) × 2.
 FIG. 13. *Spirifer raymondi* Haynes. Three Forks, Montana. (Exfoliated ventral valve, showing slight fold in sinus.) × 2.